

Conceptual Change Theories as Frameworks for Chemistry Education Research



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Outline

- Quality in Chemistry Education Research
- Constructivism
- An illustration of the problem
- Theories of conceptual change
- Implications
 - ▲ for pedagogy
 - ▲ for research

Why Education Literature Matters!

- Quality criteria in chemistry education research
 - ▲ Theory-relatedness
 - ▲ The quality of the research question
 - ▲ Methods
 - Relevance to existing literature
 - Appropriateness of the method
 - Relevance for practice
 - ▲ Quantitative methods
 - Reliability; Validity; and, Level of significance
 - Falsification of hypotheses
 - Qualitative methods
 - Documentation of procedures; Interpretation by logical inference; Systematicity; Closeness to subjects; Communicative validity; and, Triangulation

Eybe, H. and Schmidt, H.-J. (2001). Quality criteria and exemplary papers in chemistry education research. *Journal of Chemical Education*, 78(1), 1-10.

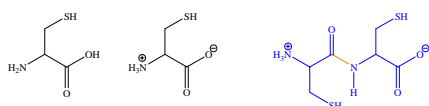
Constructivism and Conceptual Change

- Learning is an active process of sense making
- It follows that what teachers teach is different from what learners learn
- Misconceptions may arise when new information is incompatible with pre-existing knowledge or beliefs
- Process of conceptual change involves knowledge reorganisation and so requires effort

An Illustration of the Problem

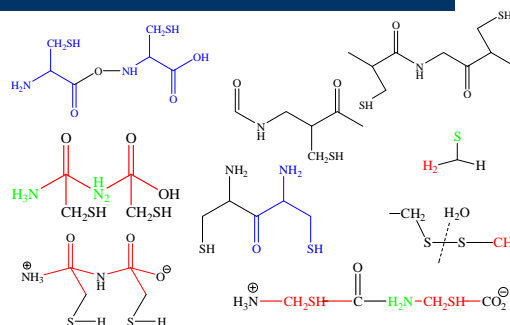
The amino acid cysteine (Cys, sidechain R= -CH₂SH) is one of twenty common amino acids found in proteins.

84 % could draw cysteine in one of its forms



47 % of this group could not correctly draw the dipeptide Cys-Cys

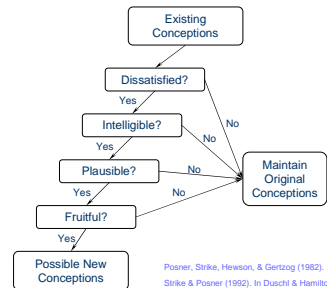
Incorrect Cys-Cys Structures



The Problem...

- Without a theoretical framework, what do I do with data of this sort...
- ...besides writing a paper saying 'look what students get wrong'
- Really want to know
 - ↳ What led the students to these answers?
 - ↳ What do I do about them in my classroom?
- These data are insufficient to answer these questions

Conceptual Change Model



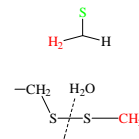
Posner, Strike, Hewson, & Gertzog (1982), *Science Education*, 66 (2), 211 – 227.
 Strike & Posner (1992), In Duschl & Hamilton (Eds) *Philosophy of Science, Cognitive Psychology, and Educational Theory and Practice*.
 Dole & Sinatra (1998), *Educational Psychologist*, 33, 109 - 128

Multiple Theories

- diSessa and *p-prims*
- Chi and ontology
- Vosniadou and synthetic models
- Social constructivism and multiple representations

diSessa (1993)

- Phenomenological Primitives (*p-prims*)
 - ↳ Discrete, unconnected pieces of inert knowledge



- ↳ "matter is continuous, but contains particles"
 - Or is that multiple representations?

diSessa (1993), *Cognition and Instruction*, 10, 105 – 225.

Chi and Ontology

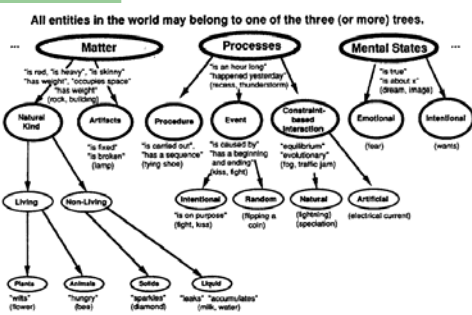


Figure 1. An epistemological supposition of the nature of our conceptions about the entities in the world. One possible categorization scheme. The three primary categories of MATTER, PROCESSES, and MENTAL STATES are ontologically distinct, and other subcategories on each tree, which are separated horizontally, may be as well.

Chi, Glaser, & de Leeuw. (1994). *Learning and Instruction*, 4(1), 27 – 43.

Vosniadou's Synthetic Models

- Arise from attempt to reconcile newly presented information with
 - ↳ Pre-existing epistemological beliefs
 - ↳ Pre-existing ontological beliefs
- Young children's models of the Earth
- "Round like a ball or round like a pancake?"

A Synthetic Model of the Earth



Vosniadou (1994), *Learning and Instruction*, 4, 45 – 69.
Schwartz & Preuß (1999). In Schwartz, Vosniadou & Carretero (Eds.), *New Perspectives on Conceptual Change*

Teaching Implications

- What to address?
 - ↳ Focus on the presuppositions, not the misconceptions
- Fish Bowl Earth
 - ↳ Earth is not hollow?
 - ↳ Earth is a sphere?
- “What children need in order to get rid of this misconception is a lesson on gravity and a lesson on how round things can sometimes appear to be flat. Otherwise, one misconception will be followed by another, and the student will remain confused.” Vosniadou (1994), *Learning and Instruction*, 4, 45 – 69.

Differences in Theories

- Vosniadou argues that the Chi and diSessa approaches are covered by her approach
 - ↳ Ontological miscategorisation is one possible cause for a synthetic model being formed
 - ↳ diSessa and Vosniadou only really differ about when a schema is formed – Vosniadou argues that formation occurs much earlier than does diSessa
 - ↳ To an extent, borne out by my data from the amino acid question – only molecular fragments are really examples of *p-prims*

Other Issues

- Motivation
 - ↳ Pintrich, Marx, and Boyle (1993)
 - ↳ Palmer (2005)
- Intention
 - ↳ Sinatra and Pintrich (2003)
- Classroom Scale
 - ↳ Tyson, Venville, Harrison and Treagust (1997)

Implications – Pedagogy

- To design an intervention, need to know
 - ↳ what students' conceptions are
 - ↳ why they arise
- May also need to know why they are resistant to change
- No information = flying blind
- Qualitative Methods are ESSENTIAL

Implications – Research

- Theoretical framework helps in
 - ↳ choosing appropriate methods
 - ↳ ensuring data can be understood
 - ↳ asking the right questions to ensure that necessary data are collected
- Important for high quality chemistry education research

Acknowledgments

- Human Research Ethics Committee
- Participating Students

- Richard Walker

- Members of the Chemistry Education Research Group of the University of Sydney

References

Reference List Handout Available

Conceptual Change section in Education Info at the ACELL website – coming soon

<http://acell.chem.usyd.edu.au>

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